North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk

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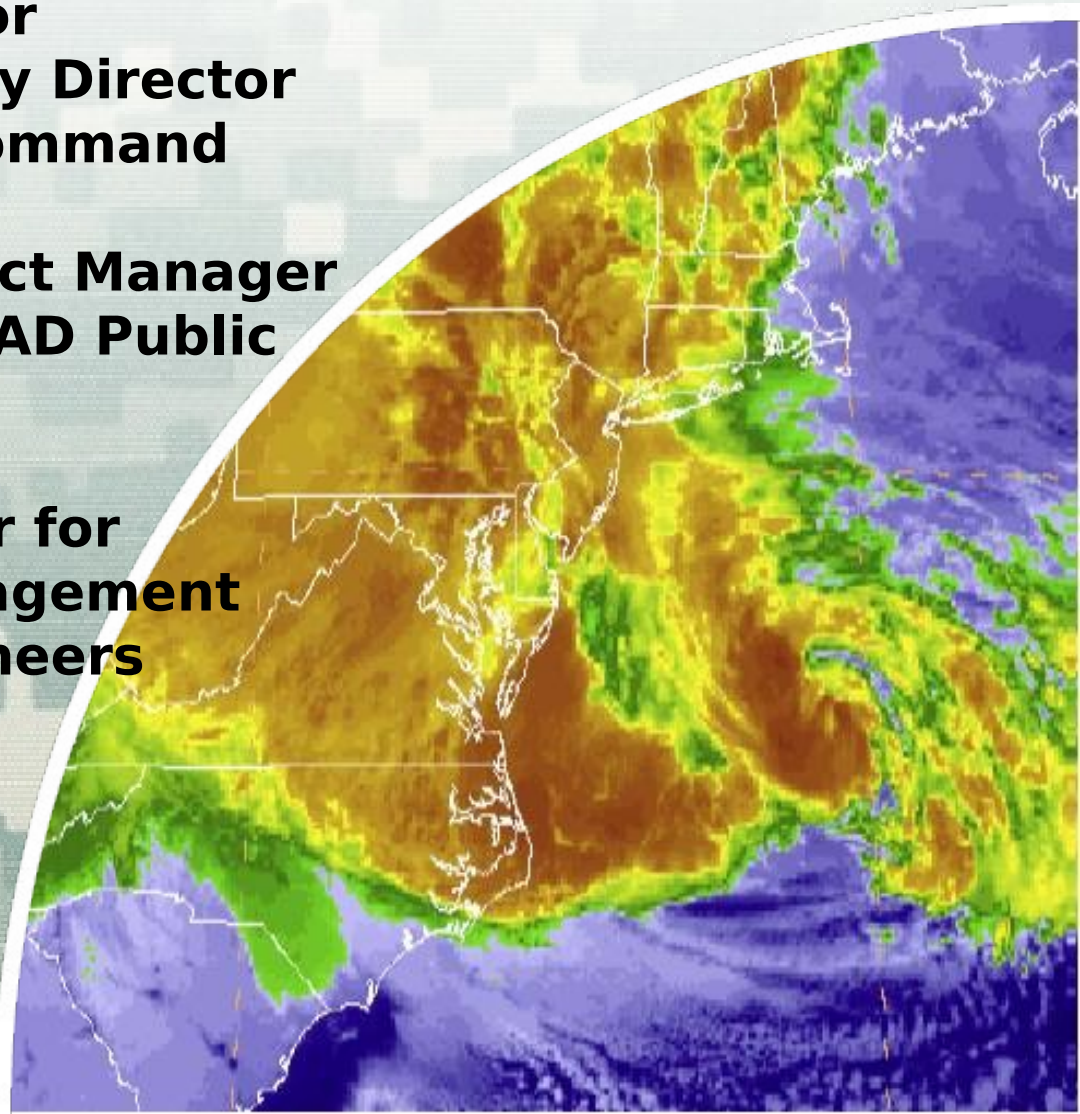
National Planning Center for Coastal Storm Risk Management
U.S. Army Corps of Engineers

28 January 2015



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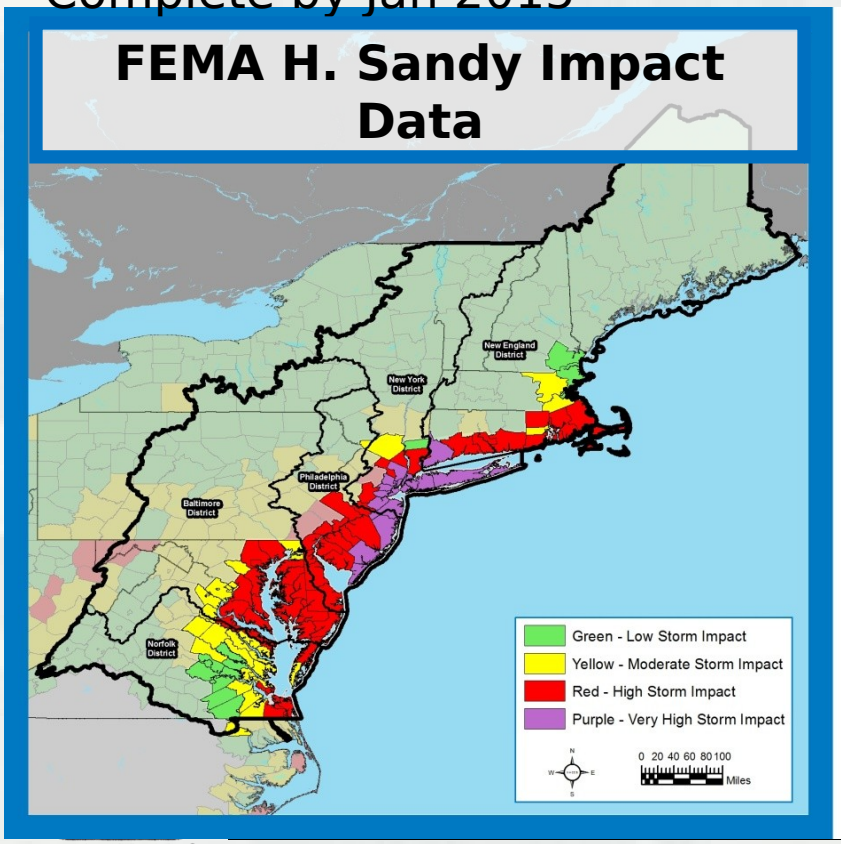
Outline

- Background
- Interagency Collaboration
- Findings, Outcomes, and Opportunities
- Coastal Storm Risk Management Framework
  - Trends
  - Flood Exposure and Risk Assessment
  - Risk Management Measures
- Technical Products Supporting the Framework
- Systems Approach and Resilience
- Institutional and Other Barriers
- Areas Warranting Additional Analysis
- Final Report
- Summary

Background

"That using up to $20,000,000* of the funds provided herein, the Secretary shall conduct a **comprehensive study** to address the flood risks of **vulnerable coastal populations** in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the Corps..." (*$19M after sequestration)

- Complete by Jan 2015



Goals

- Provide a **Risk Management Framework** , consistent with USACE-NOAA Rebuilding Principles
- Support **Resilient Coastal Communities** and robust, sustainable coastal landscape systems, considering future sea level rise and climate change scenarios, to reduce risk to vulnerable population, property, ecosystems, and infrastructure

Background

End State

- Address the legislative direction for a **comprehensive plan** to address vulnerable coastal communities
- Formalized and **consistent approach/framework** for more detailed, site specific coastal evaluations
- **Integration** of state-of-the-science techniques and collaboration
- Equip and link a broad audience and all levels of government with data, tools, and other stakeholders to make **INFORMED coastal risk management decisions**

www.nad.usace.army.mil/CompStudy

NACCS is *not*:

- A decision document authorizing design and construction
- A NEPA document evaluating impacts of any specific solution
- A USACE-only application

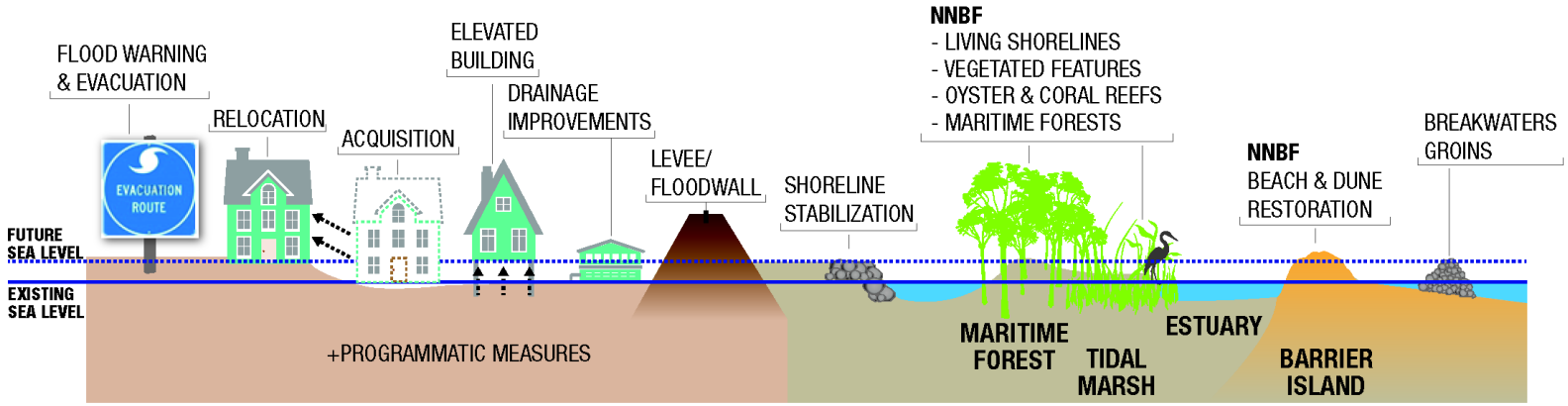
Interagency Collaboration

- **Interagency and Tribal Input**
  - Formal and informal letters and email
  - Technical working meetings
  - Tribal webinars and meeting participation
  - Panel discussions and meetings upon request
  - Subject Matter Experts embedded in team and via outreach
  - Federal Register notices
  - Public website with subscriber list and opportunity for input on resilience
  - OMB Legislative Review Memorandum with Federal Agencies

- **Interagency Webinar Collaboration Series**
  - Webinar 1 (30 July 2013) Green/Nature Based Infrastructure
  - Webinar 2 (29 August 2013) Ecosystem Goods and Services
  - Webinar 3 (12 September 2013) Numerical Modeling and Sea Level Rise
  - Webinar 4 (25 September 2013) Vulnerability Assessments
  - Webinar 5 (19 December 2013) Policy Challenges and Other Barriers
  - Webinar 6 (24 June 2014) Regional Sediment Management and Systems Approach

Findings

- **Shared** responsibility of all levels of Government and partnerships
- Rethink approaches to **adapting to risk**
- Resilience and sustainability must consider a **combination and blend** of measures



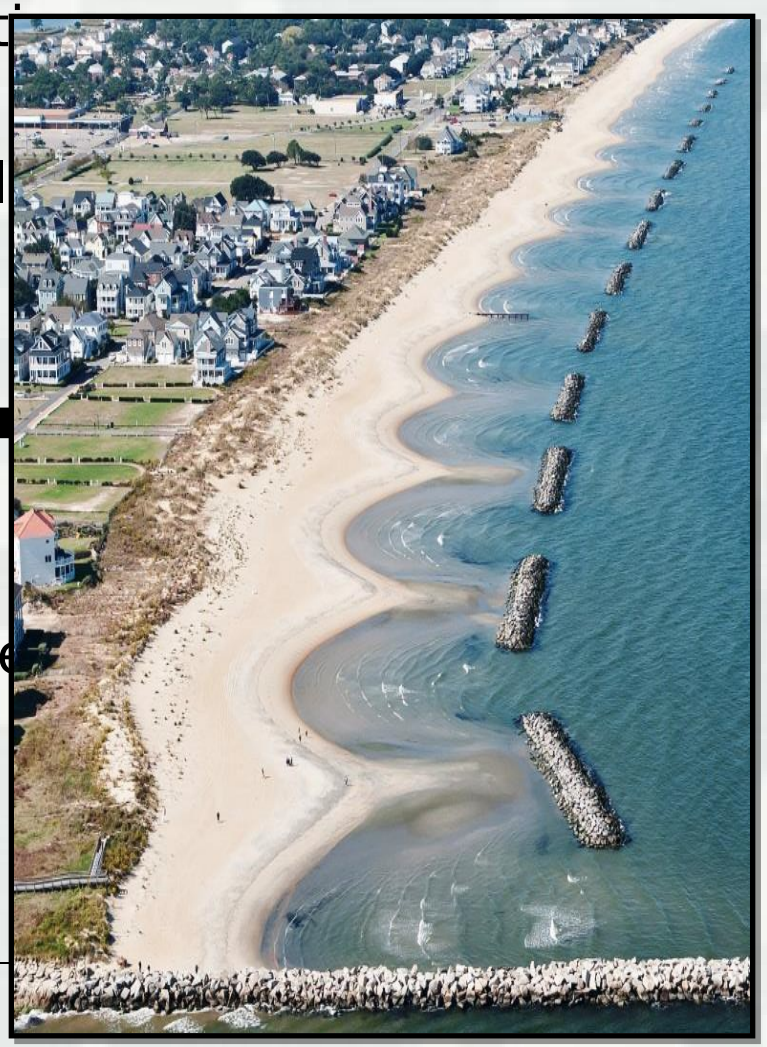
Outcomes

- **State-by-State Risk Management Frameworks informing, strengthening and catalyzing the focus on regional** resilience, redundancy and robustness in coastal planning and implementati

- **System-wide framework of sol**
  and best practices

- **Interagency and Regional alig**
  with others

- **Advanced the Science** and close
  gaps



Opportunities

- Mitigate future risk with **improved pre-storm planning**
- Identify acceptable **flood risk at a community** and state scale
- **Prioritize** critical infrastructure
- **Rebuild with redundancy**
- Develop **creative incentives** to promote use of resilience measures
- Utilize a **collaborative regional governance structure**
- Develop **Public-Private Partnerships** for coastal risk management
- Integrate **nature-based features** in coastal risk management systems
- Encourage design **flexibility and adaptive management**
- Advance efforts in the 9 focus areas:
  1) **Rhode Island Coastline**
  2) **Connecticut Coastline**
  3) **Nassau County Back Bays, NY**
  4) **New York Bay –New Jersey Harbor and Tributaries**
  5) **New Jersey Back Bays**
  6) **Delaware Back Bays**

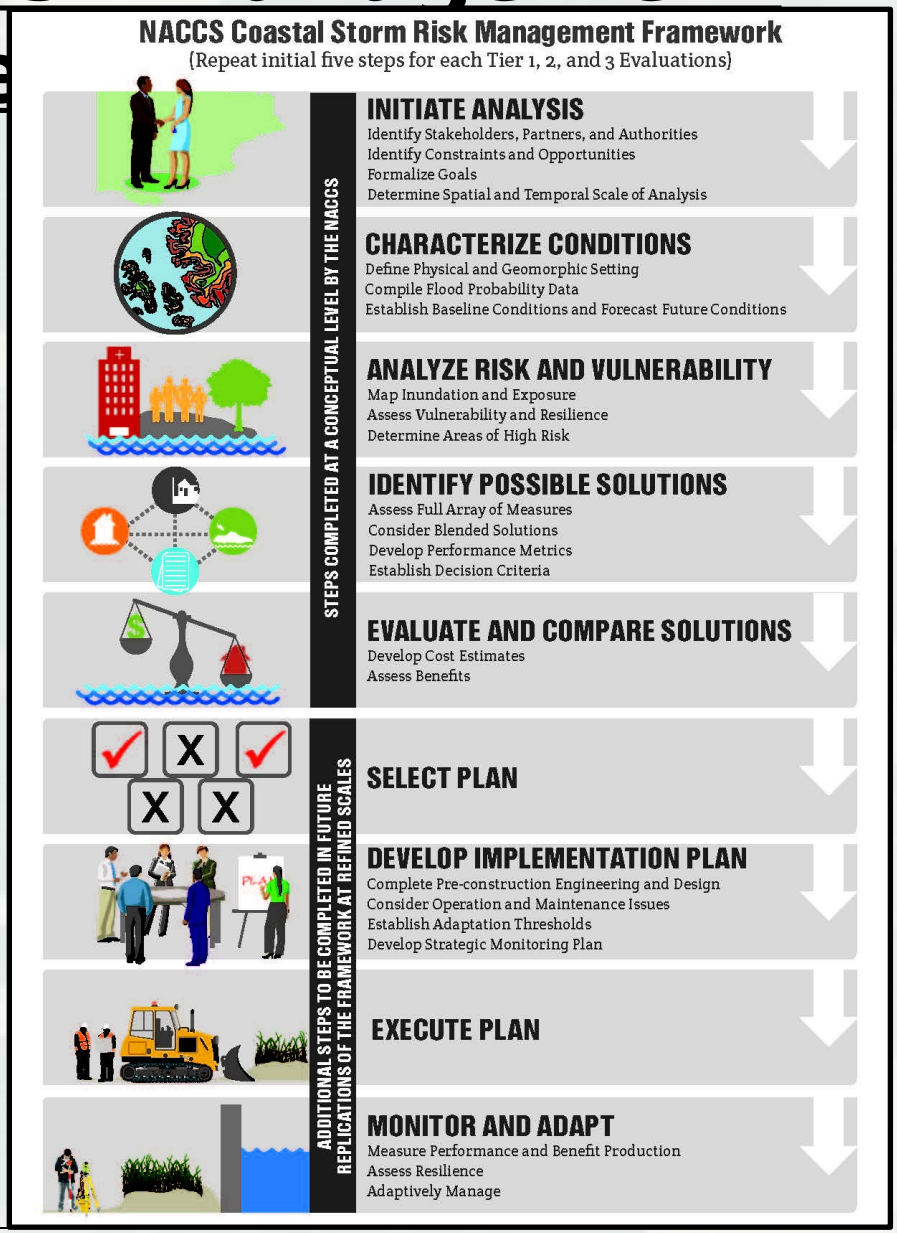
Coastal Storm Risk Management Framework

- **Who and what** is exposed to flood risk?
- **Where** is the flood risk?
- What are the **appropriate strategies** and measures to reduce flood risk?
- What is the **relative cost** of a particular strategy compared to the anticipated risk reduction?
- What **data are available** to make **RISK INFORMED decisions**?
- How can the **science be advanced/data gaps closed** through the NACCS?

Coastal Storm Risk Management Frame

- Managing coastal storm risk is a shared responsibility and requires:
  - Shared tools
  - Common methodology that all parties can follow together to assess risk and identify solutions

- The framework is:
  - A 9-step process
  - Customizable for any coastal area or watershed
  - Repeatable at state and local scales
  - Transferable to other areas of the country


NACCS Coastal Storm Risk Management Framework
(Repeat initial five steps for each Tier 1, 2, and 3 Evaluations)
STEPS COMPLETED AT A CONCEPTUAL LEVEL BY THE NACCS
INITIATE ANALYSIS
Identify Stakeholders, Partners, and Authorities
Identify Constraints and Opportunities
Formalize Goals
Determine Spatial and Temporal Scale of Analysis
CHARACTERIZE CONDITIONS
Define Physical and Geomorphic Setting
Compile Flood Probability Data
Establish Baseline Conditions and Forecast Future Conditions
ANALYZE RISK AND VULNERABILITY
Map Inundation and Exposure
Assess Vulnerability and Resilience
Determine Areas of High Risk
IDENTIFY POSSIBLE SOLUTIONS
Assess Full Array of Measures
Consider Blended Solutions
Develop Performance Metrics
Establish Decision Criteria
EVALUATE AND COMPARE SOLUTIONS
Develop Cost Estimates
Assess Benefits
ADDITIONAL STEPS TO BE COMPLETED IN FUTURE REPLICATIONS OF THE FRAMEWORK AT REFINED SCALES
SELECT PLAN
DEVELOP IMPLEMENTATION PLAN
Complete Pre-construction Engineering and Design
Consider Operation and Maintenance Issues
Establish Adaptation Thresholds
Develop Strategic Monitoring Plan
EXECUTE PLAN
MONITOR AND ADAPT
Measure Performance and Benefit Production
Assess Resilience
Adaptively Manage

Coastal Storm Risk Management Framework

Trends

- **Climate and Sea Level Change**
  - Sea level is increasing throughout the study area
  - Shorelines are changing in response to sea level change
  - Historic erosion patterns will continue and accelerate
- **Socioeconomic Trends**
  - Population is aging (i.e. more difficult to evacuate/relocate during flooding)
  - Population is increasing in coastal zone (more people exposed to flooding)
  - Importance of operating channels and ports will become more critical to regional and national economy
- **Environmental Trends**
  - Habitats subject to more stress with population increase, climate change, and other effects

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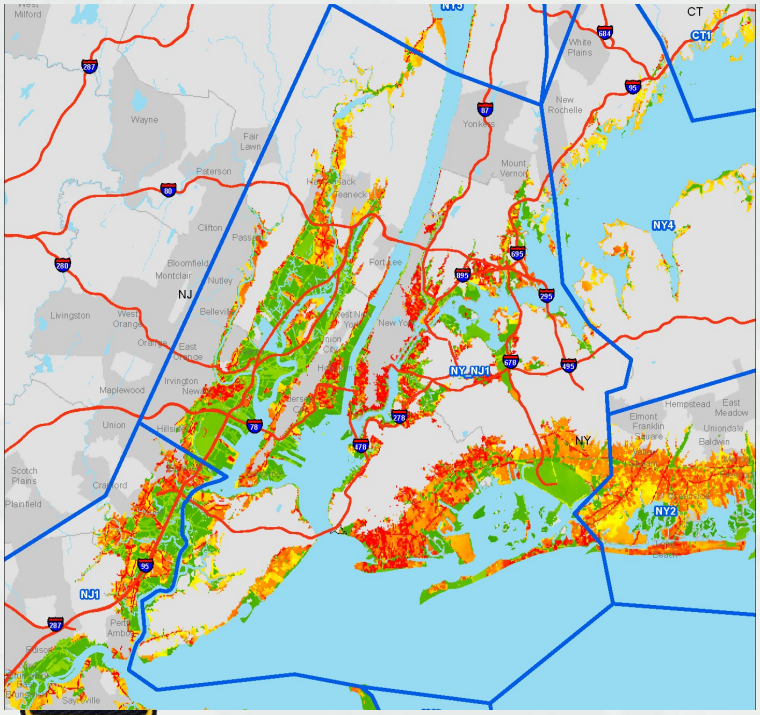
Coastal Storm Risk Management Framework

Flood Exposure & Risk Assessment

Coastal Flood

- SLOSH CAT1-4 Maximum of Maximum
- FEMA DFIRM
- 10-percent-annual chance
- SLR Inundation (USACE high)



Exposure Indices

- **Population density and infrastructure** (number of people and infrastructure in communities subject to flooding)
- **Socioeconomic groups** (populations that may have more difficulty preparing and responding to flooding)
- **Environmental & Cultural** (critical habitat, wetlands and other areas that maintain resiliency during flooding; key cultural resources subject to flooding)
- **Composite**

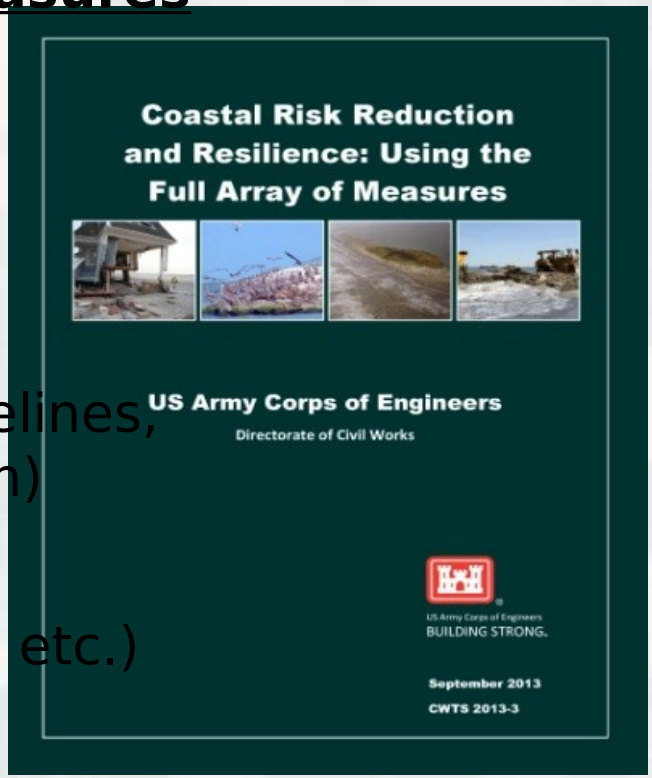
Mapping

- Flood Hazard
- Relative Exposure
- Relative Risk

Coastal Storm Risk Management Framework

Risk Management Measures

- **Structural**
  - Storm surge barriers
  - Levees, breakwaters, shoreline stabilization
  - Natural and Nature-Based Features (e.g., beaches and dunes, living shorelines, wetlands, oyster reefs, SAV restoration)
- **Non-Structural** (e.g., floodproofing, acquisition and relocation, flood warning, etc.)
- **Programmatic** (e.g., floodplain management, land use planning, State/municipal policy, natural resources, surface water management, education, flood insurance programs, etc.)


Coastal Risk Reduction and Resilience: Using the Full Array of Measures
US Army Corps of Engineers
Directorate of Civil Works
US Army Corps of Engineers
BUILDING STRONG.
September 2013
CWTS 2013-3

Coastal Storm Risk Management Framework

Tier 1 Analysis

- **Initial Screening**
- **Aggregated Measures**
- **Evaluated Applicability of Measures given Shoreline Type**
- **Next Step: Tier 2 and Tier 3 Analyses at smaller (more localized) scales**

Risk Management Measures

Table VIII-2. Structural and NNBF Measure Applicability by NOAA-ESI Shoreline Type

Measures	Rocky shores (Exposed)	Rocky shores (Sheltered)	Beaches (Exposed)	Manmade structures (Exposed)	Manmade structures (Sheltered)	Scarps (Exposed)	Scarps (Sheltered)	Vegetated low banks (Sheltered)	Vegetated low banks (Sheltered)	Wetlands/Marshes/ Swamps (Sheltered)
Structural										
Storm Surge Barrier[1]										
Beach Restoration[2]			x							
Breakwaters and Beach Restoration[2]			x							
Groins and Beach Restoration			x							
Shoreline Stabilization						x	x	x		
Deployable Floodwall					x					
Floodwall/Levee		x			x			x		
Drainage Improvements	x	x	x	x	x	x	x	x	X	x
Natural and Nature-Based Features										
Living Shoreline						X	x	x		X
Wetlands							x			X
Reefs	x	x				X				X
Submerged Aquatic Vegetation (SAV) Restoration[3]										X
Overwash Fan[4]										
Drainage Improvements	x	x	x	x	x	x	x	x	X	X

[1] *The applicability of storm surge barriers cannot be determined based on shoreline type. It depends on other factors such as coastal geography.*

[2] *Beaches and dunes are also considered Natural and Nature-Based Features.*

[3] *SAV restoration is not associated with any particular shoreline type. It is initially assumed to apply to wetland shorelines.*

[4] *Overwash fans may apply to the back side of barrier islands, which are not explicitly identified in the NOAA Environmental Sensitivity Index Shoreline Classification dataset.*

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Coastal Storm Risk Management Framework:

Risk Management Measures

Natural and Nature-Based Infrastructure at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM INTENSITY, TRACK, AND FORWARD SPEED, AND SURROUNDING LOCAL BATHYMETRY AND TOPOGRAPHY

Dunes and Beaches

Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer

Performance Factors
Berm height and width
Beach Slope
Sediment grain size and supply
Dune height, crest, width
Presence of vegetation

Vegetated Features: Salt Marshes, Wetlands, Submerged Aquatic Vegetation (SAV)

Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer
Increase infiltration

Performance Factors
Marsh, wetland, or SAV elevation and continuity
Vegetation type and density

Oyster and Coral Reefs

Benefits/Processes
Break offshore waves
Attenuate wave energy
Slow inland water transfer

Performance Factors
Reef width, elevation and roughness

Barrier Islands

Benefits/Processes
Wave attenuation and/or dissipation
Sediment stabilization

Performance Factors
Island elevation, length, and width
Land cover
Breach susceptibility
Proximity to mainland shore

Maritime Forests/Shrub Communities

Benefits/Processes
Wave attenuation and/or dissipation
Shoreline erosion stabilization
Soil retention

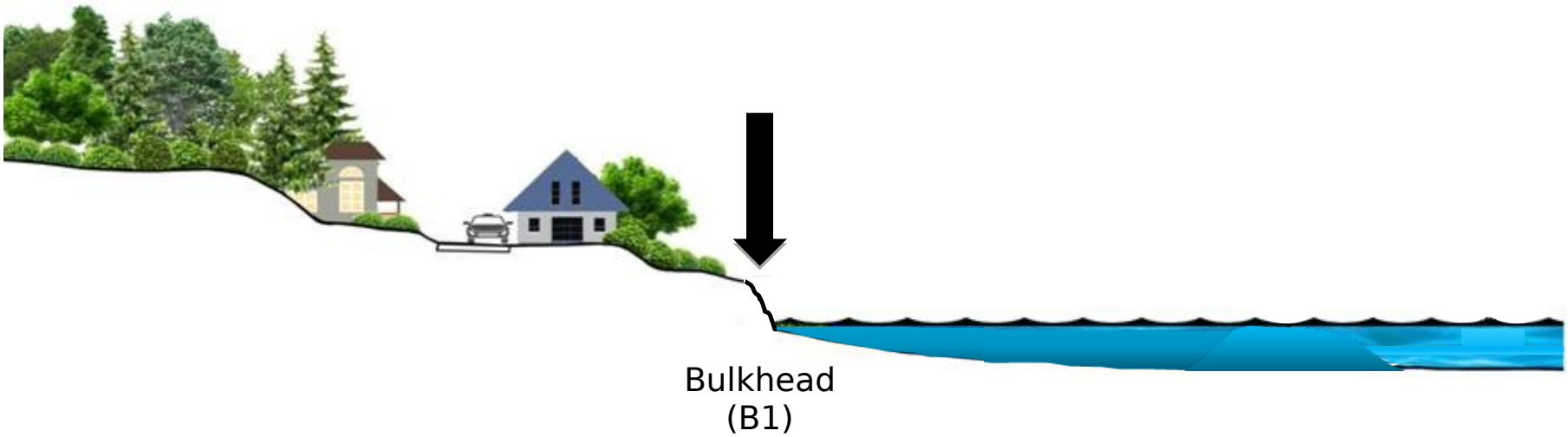
Performance Factors
Vegetation height and density
Forest dimension
Sediment composition
Platform elevation

Natural and Nature-Based Features

Coastal Storm Risk Management Framework:
Risk Management Measures

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✔				
S2	✔				
S3					
S4					
S5					
S6					

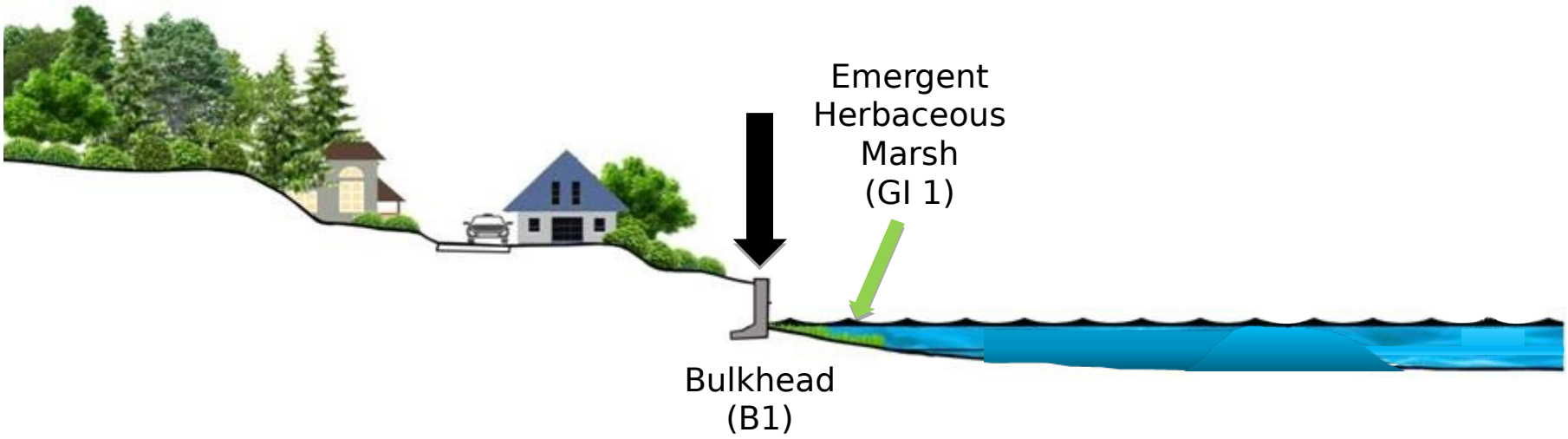
Integration of Measures



Coastal Storm Risk Management Framework:
Risk Management Measures

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✔				
S2	✔				
S3					
S4					
S5		✔			
S6		✔			

Integration of Measures



Coastal Storm Risk Management Framework:

Risk Management Measures

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✓		✓		
S2	✓		✓	✓	
S3			✓		
S4				✓	
S5		✓	✓		
S6		✓		✓	

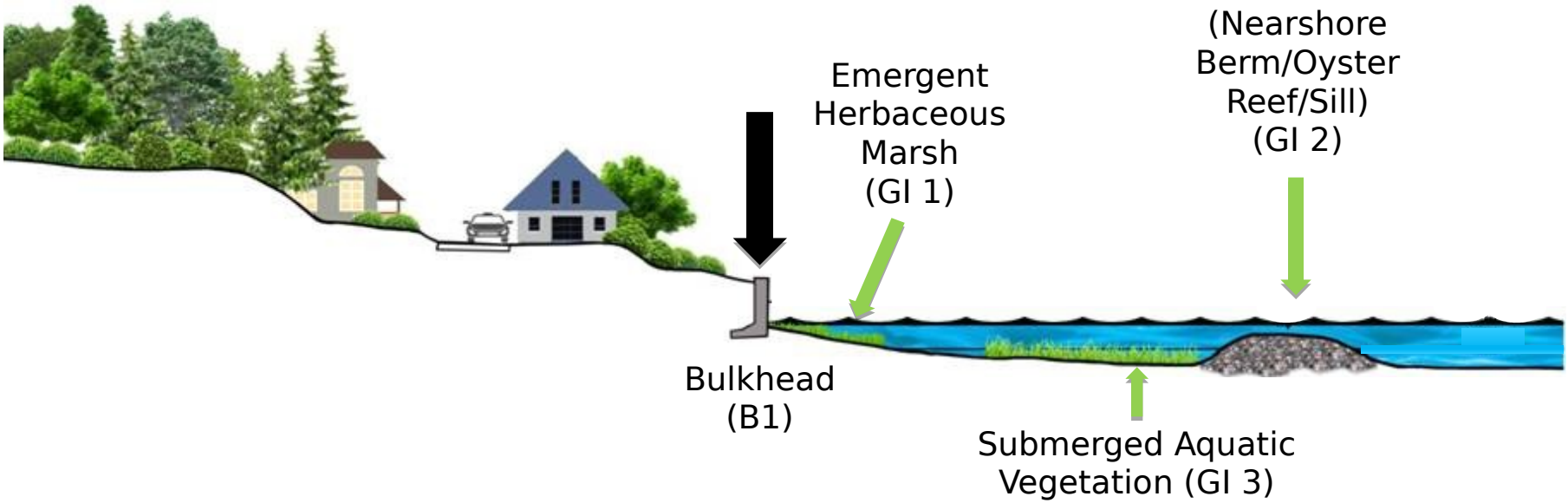
Integration of Measures

Coastal Storm Risk Management Framework:

Risk Management Measures

	SB1	NBI 1	NBI 2	NBI 3	ALL
S1	✔		✔		✔
S2	✔		✔	✔	✔
S3			✔		✔
S4				✔	✔
S5		✔	✔		✔
S6		✔		✔	✔

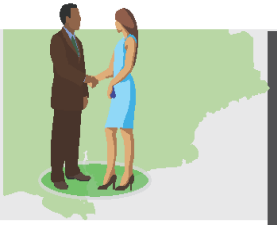
Integration of Measures


Submerged Breakwater (Nearshore Berm/Oyster Reef/Sill) (GI 2)
Emergent Herbaceous Marsh (GI 1)
Bulkhead (B1)
Submerged Aquatic Vegetation (GI 3)

Technical Products Supporting the Framework

NACCS Coastal Storm Risk Management Framework

STEPS COMPLETED AT A CONCEPTUAL LEVEL BY THE NACCS

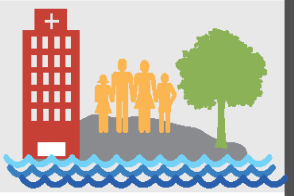


INITIATE ANALYSIS
Identify Stakeholders, Partners, and Authorities
Identify Constraints and Opportunities
Formalize Goals

Technical Products Advanced by NACCS to Close Identified Data Gaps
- Visioning Sessions Report & Focus Area Analyses
- Institutional & Other Barriers Report

CHARACTERIZE EXISTING CONDITIONS
Define Physical and Geomorphic Setting
Compile Flood Probability Data
Establish Baseline Conditions

- NACCS GIS Geodatabase
- Environmental & Cultural Resources Conditions Report



ANALYZE VULNERABILITY AND RISK
Map Inundation and Exposure
Assess Vulnerability and Resilience
Determine Areas of High Risk

- Storm Suite Modeling
- NACCS GIS Geodatabase
- NACCS Barrier Island Sea Level Rise Inundation Assessment Report

IDENTIFY POSSIBLE SOLUTIONS
Assess Full Array of Measures
Consider Blended Solutions
Develop Performance Metrics
Establish Decision Criteria

- Natural & Nature-Based Features Report
- Conceptual Regional Sediment Budget
- State Appendix
- Vulnerability Decision Tree

EVALUATE AND COMPARE SOLUTIONS
Develop Cost Estimates
Assess Benefits

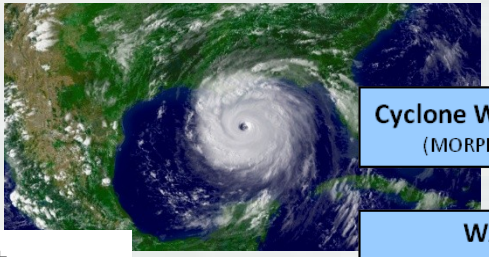
- Enhanced Depth-Damage Functions for Coastal Storms

Several products, planning tools, and models were developed to assist decision makers in navigating the Coastal Storm Risk Management Framework

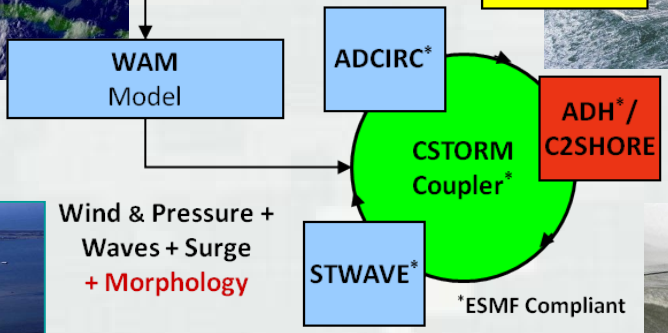
Technical Products Supporting the Framework

Coastal Storm-Modeling System (ERDC CSTORM-MS)

Provides for a robust, standardized approach to establishing the risk of coastal communities to future occurrences of storm events.



Not just hurricanes and not just in the Gulf of Mexico



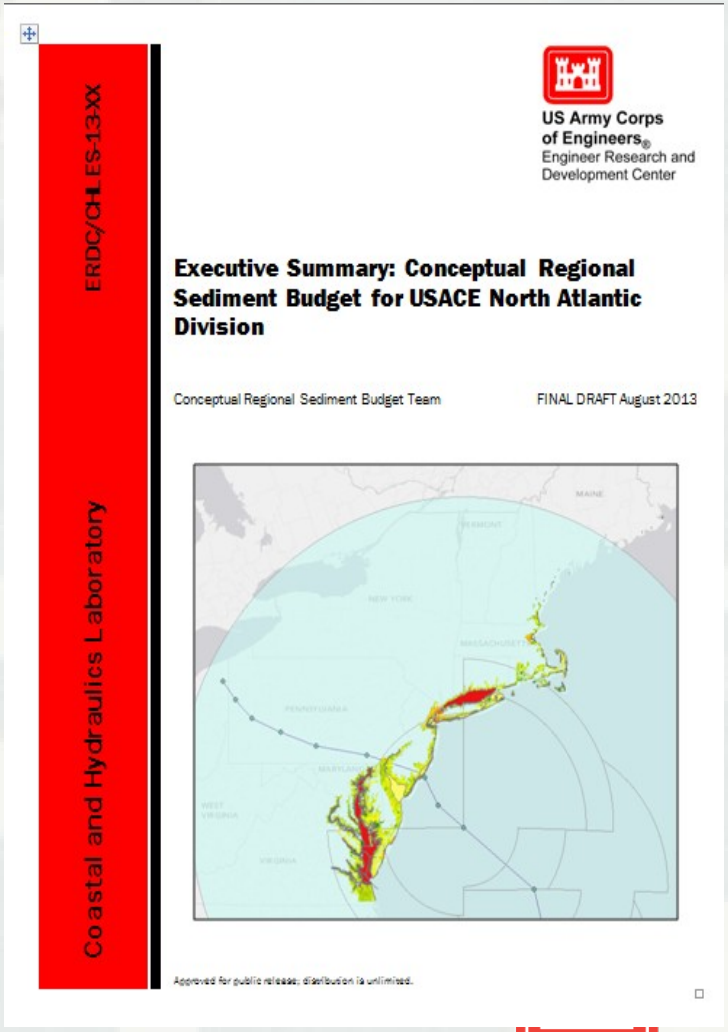
Expandable and upgradeable system

- Application of high-resolution, highly skilled numerical models in a tightly integrated modeling system with user friendly interfaces

Technical Products Supporting the Framework

Conceptual Regional Sediment Budget

- Enables and promotes a systems approach
- Visualizes magnitude and direction of sediment transport
- Includes dredging data from Dredging Information System and placement site (if available)
- Based on existing knowledge or morphology


ERDC/CHL ES-13-XX
Coastal and Hydraulics Laboratory
US Army Corps of Engineers®
Engineer Research and Development Center
Executive Summary: Conceptual Regional Sediment Budget for USACE North Atlantic Division
Conceptual Regional Sediment Budget Team
FINAL DRAFT August 2013
Approved for public release; distribution is unlimited.

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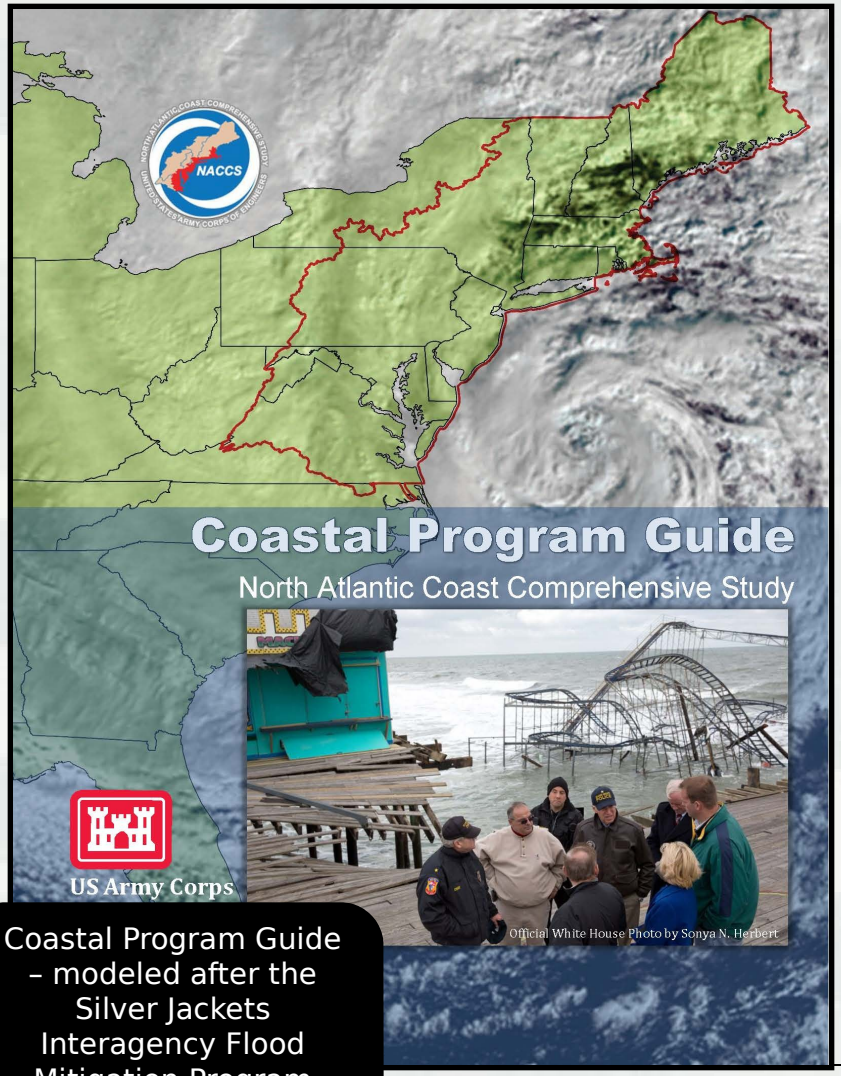
Technical Products Supporting the Framework

Coastal Program Guide


NACCS
Coastal Program Guide
North Atlantic Coast Comprehensive Study
US Army Corps
Official White House Photo by Sonya N. Herbert

Coastal Program Guide – modeled after the Silver Jackets Interagency Flood Mitigation Program Guide

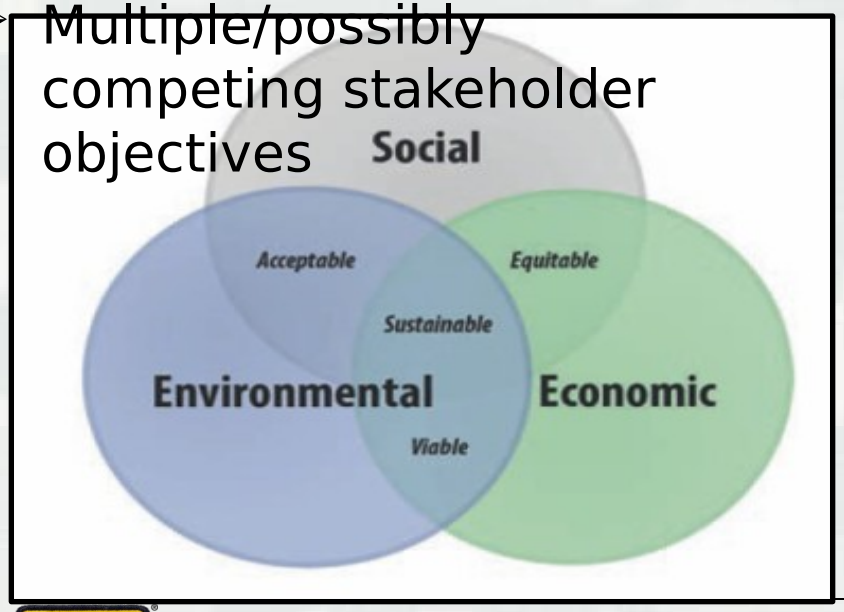
U.S. Fish and Wildlife Planning Aid Report

U.S. Fish & Wildlife Service
North Atlantic Coast Comprehensive Study
Biological Resources and Habitats Vulnerable to Sea Level Rise and Storm Activity in the Northeast U.S.
Photo by JF Photography 2006

Systems Approach and Resilience

Why a Systems Approach?

- Coastal change occurs over large temporal and spatial scales
- Complex social, economic, and environmental interactions
- Multiple/possibly competing stakeholder objectives



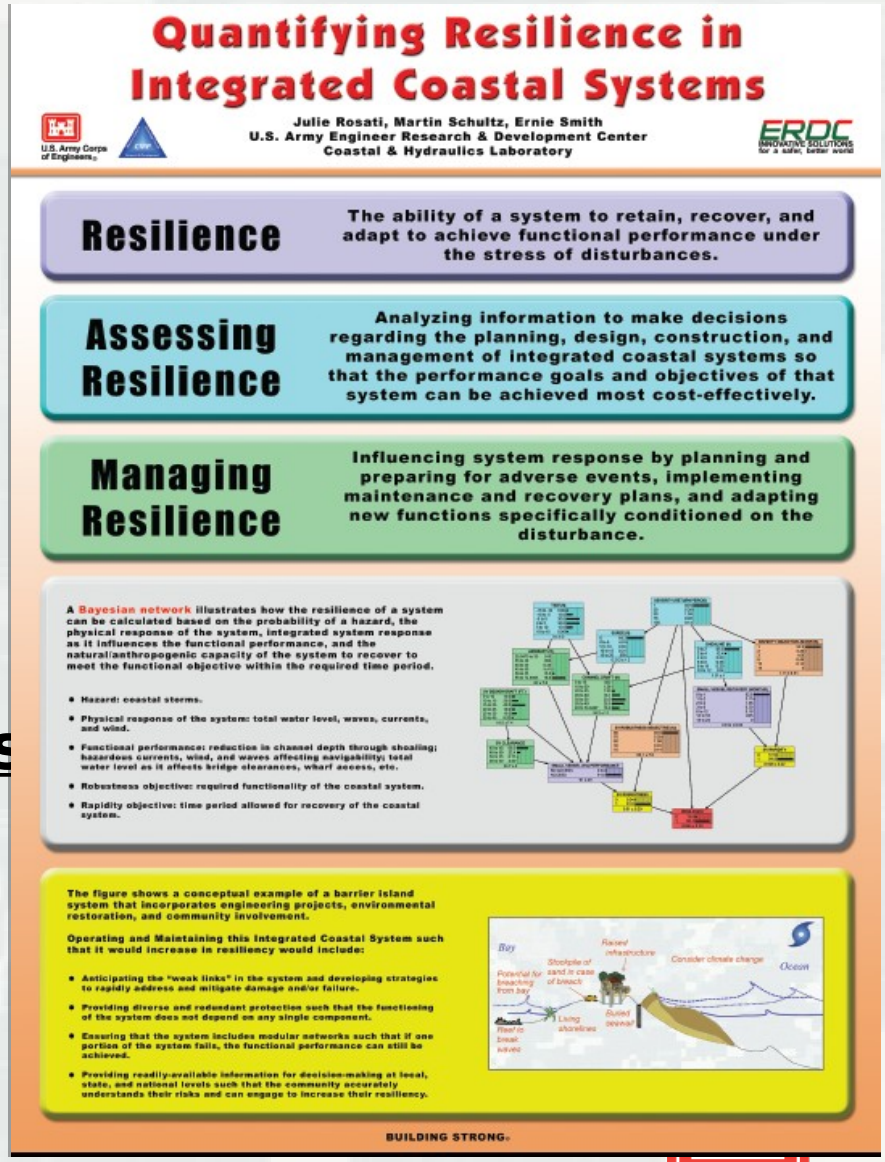
- Systems Approach:
  - *Broad view of interactions & objectives to develop potential solution sets*
  - *Intentionally aligns engineering and n*

Restoration of Deer Island, MS Barrier Island and Marsh

Systems Approach and Resilience

- **Quantify the resilience**
  - Natural & Nature-Based Features
  - Engineering Projects
  - Community Values
  - And more…

- What are the **best practices** for assessing, operating and maintaining a resilient and integrated coastal system?



Quantifying Resilience in Integrated Coastal Systems

Julie Rosati, Martin Schultz, Ernie Smith
U.S. Army Engineer Research & Development Center
Coastal & Hydraulics Laboratory

ERDC
INNOVATIVE SOLUTIONS for a safer, better world

Resilience — The ability of a system to retain, recover, and adapt to achieve functional performance under the stress of disturbances.

Assessing Resilience — Analyzing information to make decisions regarding the planning, design, construction, and management of integrated coastal systems so that the performance goals and objectives of that system can be achieved most cost-effectively.

Managing Resilience — Influencing system response by planning and preparing for adverse events, implementing maintenance and recovery plans, and adapting new functions specifically conditioned on the disturbance.

A Bayesian network illustrates how the resilience of a system can be calculated based on the probability of a hazard, the physical response of the system, integrated system response as it influences the functional performance, and the natural/anthropogenic capacity of the system to recover to meet the functional objective within the required time period.

- Hazard: coastal storms.
- Physical response of the system: total water level, waves, currents, and wind.
- Functional performance: reduction in channel depth through shoaling; hazardous currents, wind, and waves affecting navigability; total water level as it affects bridge clearances, wharf access, etc.
- Robustness objective: required functionality of the coastal system.
- Rapidity objective: time period allowed for recovery of the coastal system.

The figure shows a conceptual example of a barrier island system that incorporates engineering projects, environmental restoration, and community involvement.

Operating and Maintaining this Integrated Coastal System such that it would increase in resiliency would include:

- Anticipating the "weak links" in the system and developing strategies to rapidly address and mitigate damage and/or failure.
- Providing diverse and redundant protection such that the functioning of the system does not depend on any single component.
- Ensuring that the system includes modular networks such that if one portion of the system fails, the functional performance can still be achieved.
- Providing readily-available information for decision-making at local, state, and national levels such that the community accurately understands their risks and can engage to increase their resiliency.

Bay · Ocean · Consider climate change · Living shorelines

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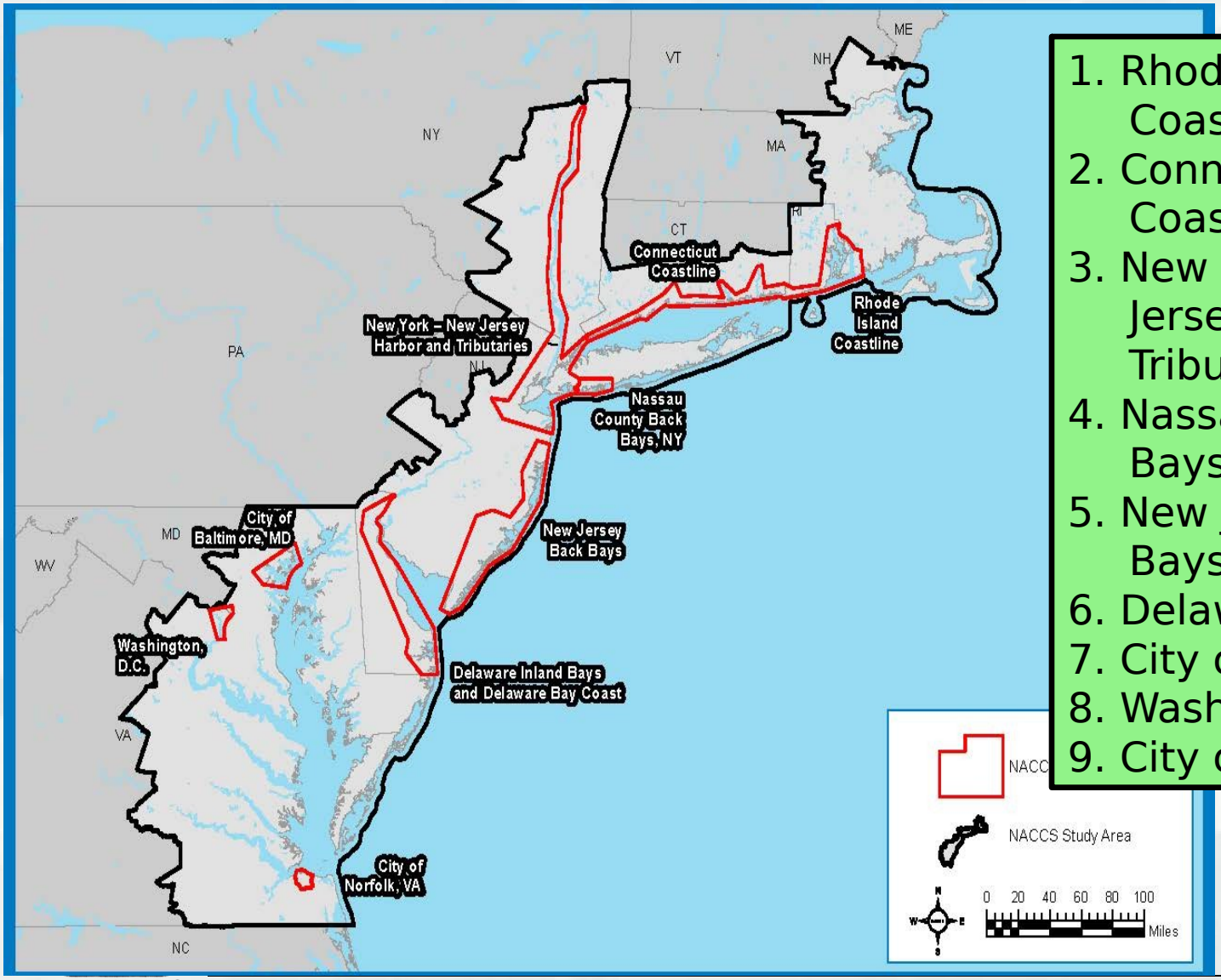
Institutional and Other Barriers

- Six themes
  - Theme 1: Risk/Resilience Standards
  - Theme 2: Communication and Outreach
  - Theme 3: Risk Management
  - Theme 4: Science, Engineering and Technology
  - Theme 5: Leadership and Institutional Coordination
  - Theme 6: Local Planning and Financing

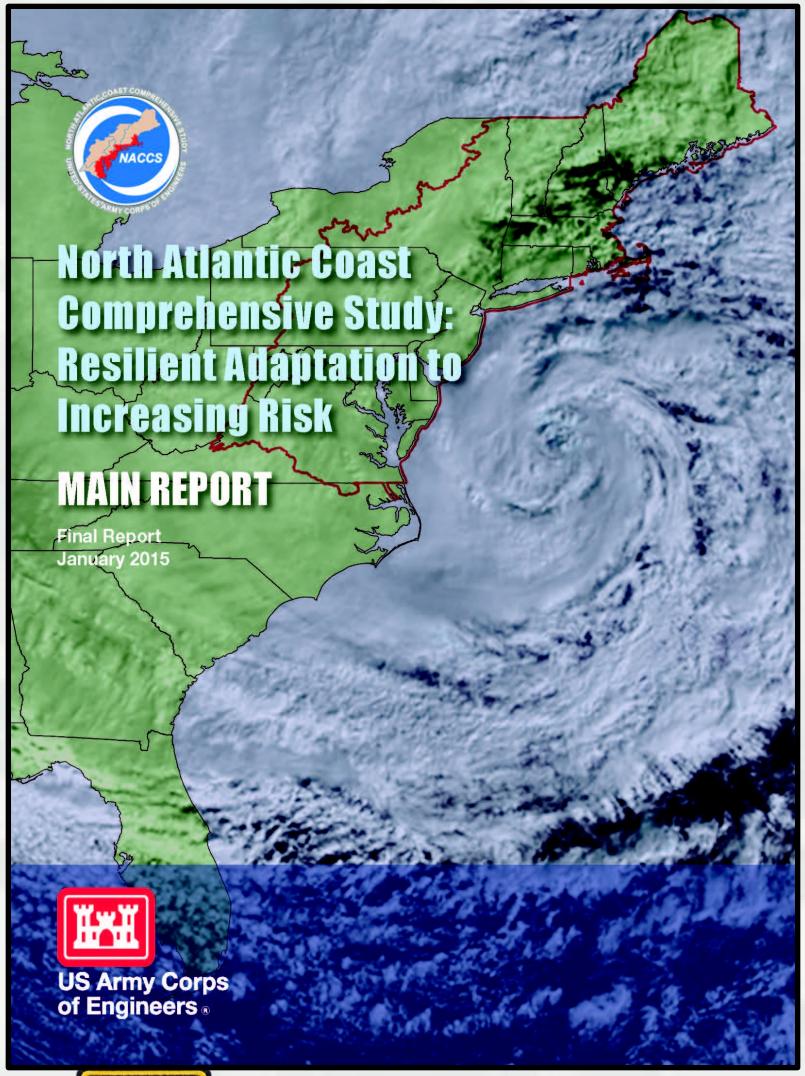
- Aligned with Project Performance Evaluation Report and Hurricane Sandy Rebuilding Strategy

Areas Warranting Additional Analysis



1. Rhode Island Coastline
2. Connecticut Coastline
3. New York - New Jersey Harbor and Tributaries
4. Nassau County Back Bays, NY
5. New Jersey Back Bays
6. Delaware Back Bays
7. City of Baltimore, MD
8. Washington, D.C.
9. City of Norfolk, VA

Final Report



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Summary

"The North Atlantic Coast Comprehensive Study is an unprecedented effort by the U.S. Army Corps of Engineers in collaboration with our partners to develop a coastal plan that considers future sea levels and climate change. The report provides a framework for communities that will arm them for the reality of future extreme weather."

Jo-Ellen Darcy
Assistant Secretary of the Army
for Civil Works

"Hurricane Sandy brought to light the reality that coastal storms are intensifying and that sea-level rise and climate change will only heighten the vulnerability of coastal communities. Coastal storm risk management is a shared responsibility, and we believe there should be shared tools used by all decision makers to assess risk and identify solutions. This report provides those tools."

g. Gen. Kent D. Savre
nding General
S. Army Corps of Engineers
rth Atlantic Division